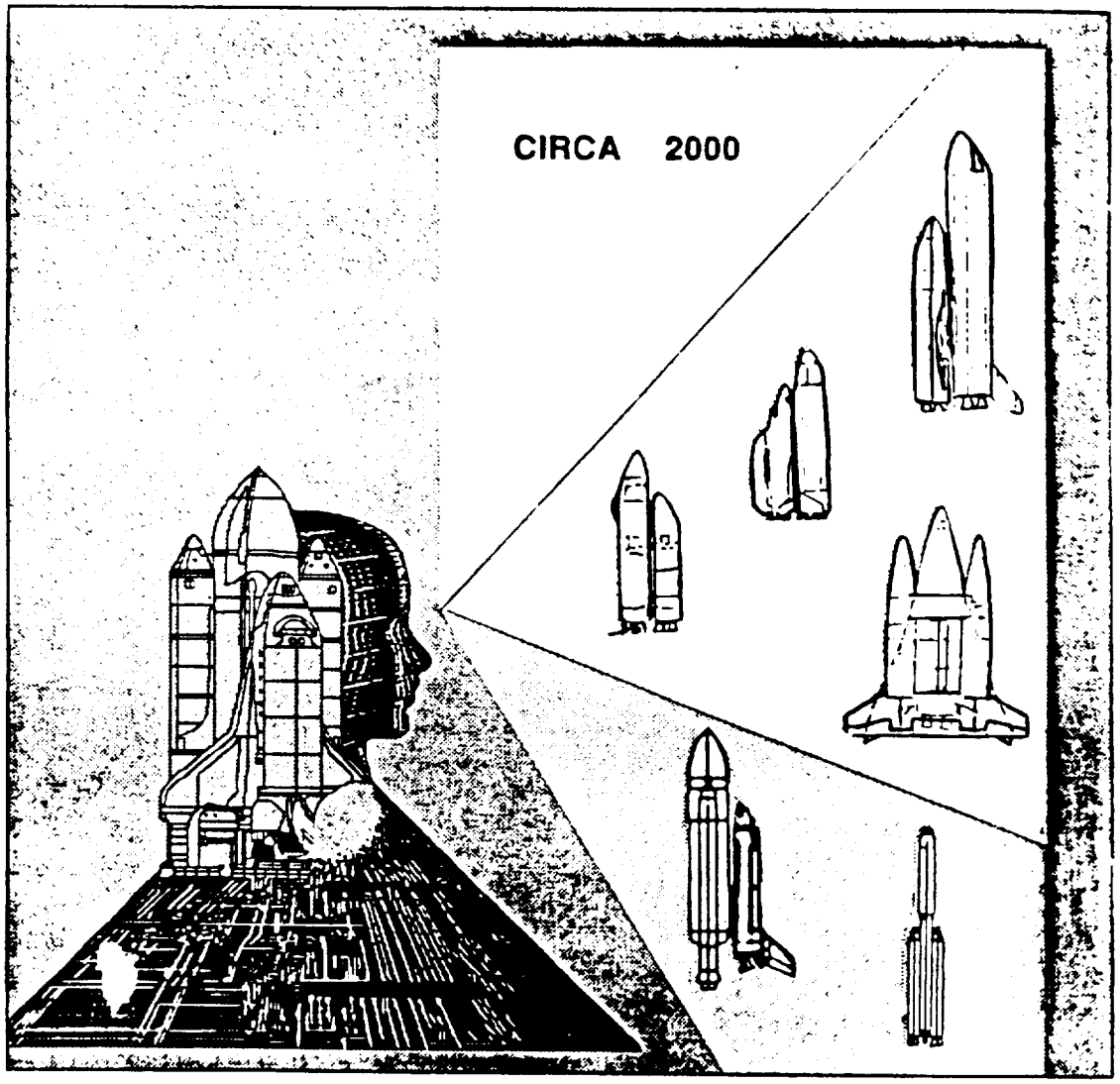
Shuttle Ground Operations Efficiencies/Technologies Study

BOEING

AEROSPACE OPERATIONS



FINAL REPORT PHASE 3
Volume 1 of 4

EXECUTIVE SUMMARY

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SPACE SHUTTLE GROUND OPERATIONS EFFICIENCIES/TECHNOLOGIES STUDY

PHASE 3 FINAL REPORT

This executive summary is the final report for this Study and covers the completion of Phase 3 of the Shuttle Ground Operations Efficiencies / Technologies Study (NAS10-11344). It briefly reviews Phase 1 and Phase 2 activities while providing more details of the Phase 3 activities.

The purpose of the Study was to identify technologies and methodologies that would enhance operational efficiencies for future launch vehicle programs

The Study was initiated by joint NASA/AF effort. It was initially funded by the Air Force Space Technology Center Kirtland AFB NM (Lt. Col. F. Gasperich) and managed by NASA-KSC. The Study started May 30, 1986, and completed May 4, 1989 was a fixed price, 1 year contract with two fixed price, 1 year options. Total funding for the Study was approximately $1.4M. The Phase 1 and Phase 2 Final Reports (approximately 1,500 pages each) were released as shown in Figure 1 and below:

Phase 1 Final Report, five volumes, dated May 4, 1987

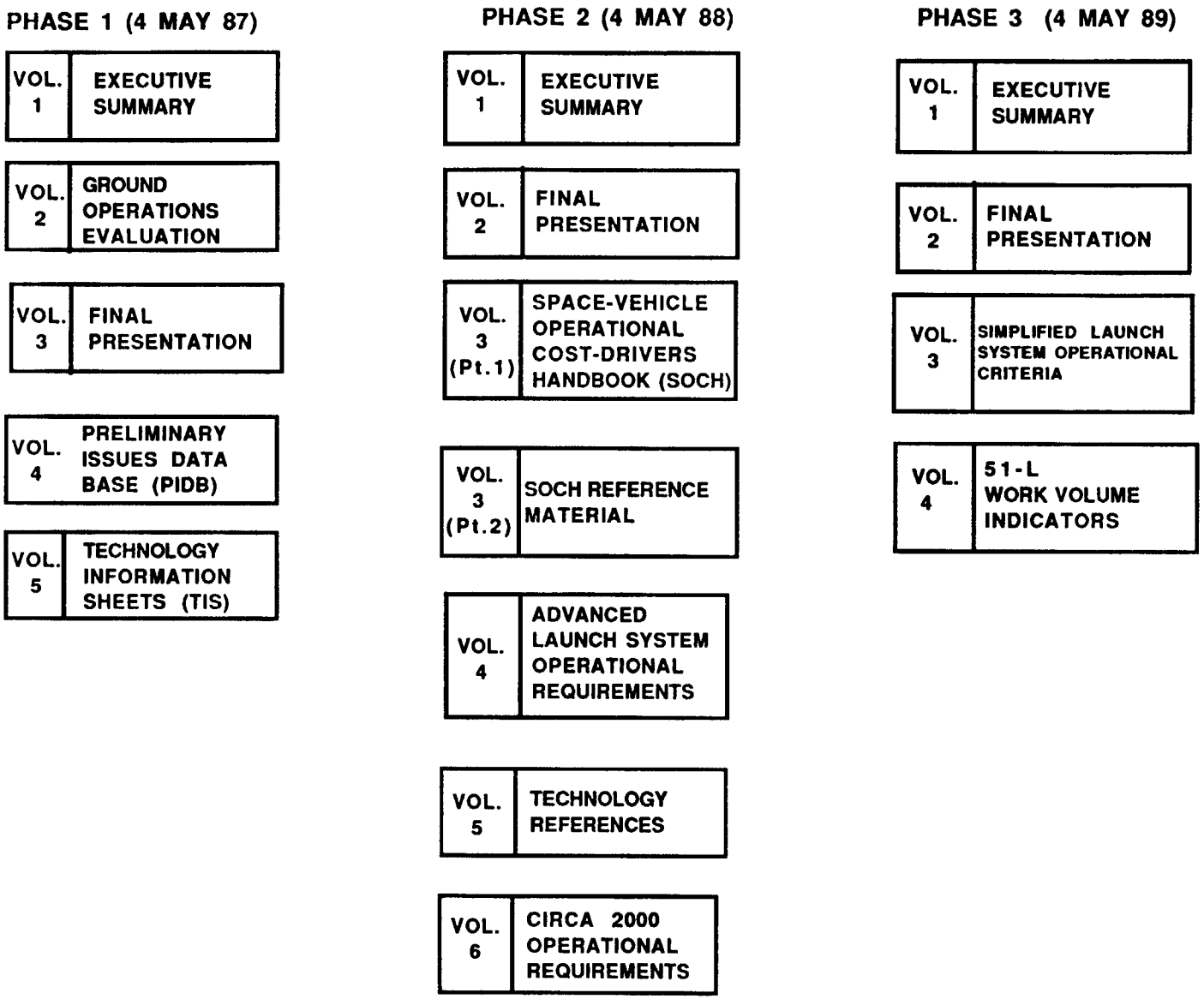
Phase 2 Final Report, six Volumes, dated May 5, 1988

Phase 3 Final Report, four Volumes, dated May 4, 1989.

Final Reports from the first two Phases of this Study are available thru all NASA Center libraries. The Phase 3 Final Report will be deposited in a similar fashion as soon as possible after its release.

Phase 1 activities were initiated to collect information and start the analyses of launch vehicle processing information from the on-going Shuttle program. A conceptual launch vehicle, processing facilities, and processing concepts, utilizing Phase 1 information to significantly reduce Life Cycle Costs, was derived in Phase 2. Phase 3 then assembled a package that was presented in a two day Workshop to 40 to 55 ALS contractor personnel and 6 or 7 government personnel at each Contractor's location (see Figure 3). These Workshops provided for the distribution of operational efficiencies recommendations developed during the Study to the working level, both government and contractor, for use in the earliest possible stages of developing the ALS Program concepts.

SGOE/T STUDY DOCUMENTATION AVAILABLE



Executive Summary
Figure 1

Representative presentation material was developed and presented at many different locations to the various Agency and contractor personnel including the following:

NASA Headquarters	AFOTEC (Kirtland)
Air Force Space Division	JSC
Rockwell	MSFC
Rocketdyne	LaRc
Boeing	26th Space Congress

Study Objectives

PHASE 1 (30 May '86 -- 4 May '87)

Objectives of Phase 1 were to define methods and technologies to reduce the cost of overall operations for a major space program. Space Shuttle processing at KSC was designated as the working model to be used as the source of operational information. The study addressed methods of improving efficiency of ground operations and identified new technology elements that could reduce operational processing costs. Study emphasis was on specific technology items and management approaches required to develop and support efficient ground operations. Prime study results were:

1) Recommendations on "how to achieve" more efficient operations

2) Identification of existing, or new technology that would make vehicle processing in both current and future programs more efficient, and; therefore, less costly.

PHASE 2 (5 May '87 -- 4 May '88)

Objective of Phase 2 was to expand Phase 1 data and analyses, and apply those elements to the next generation of launch vehicles. Inclusive to those objective were:

1) Identification of significant operations cost drivers or requirements that affect efficiency of ground support operations.

2) Highlighting new and developing technologies that apply to subjects of the study.

3) Conceptual applications of those technologies and cost drivers identified in the study to ALS program requirements, resulting in the SLSOC (Simplified Launch Systems Operational Criteria).

PHASE 3 (5 May '8 -- 4 May '89)

Objective of Phase 3 was to apply the "lessons learned" and analytical data developed during Phases 1 and 2 . Material was developed for ground operations cost driver workshops and workshops were conducted at the ALS contractors locations. The ALS contractor workshops highlighted:

1) The SLSOC.
2) Supporting rationale.
3) The need to evaluate the impact(s) of ground operations on their various trade studies, analyses, and design concepts.

Overall Study Conclusions

PHASE 1

Conclusions of the Phase 1 study centered on management issues, Shuttle operations analyses, technology applications, new vehicles, and facilities. The following are paraphrased from those conclusions presented in the Phase 1 Executive Summary:

Management Issues

A major issue was the need to accept/endorse new management concepts and practices. In particular, the need for up-front hardware supportability and maintainability analyses was stressed. The use of design/build teams and the universal availability of applicable information to all via a Unified Life Cycle Engineering (ULCE) concept being developed by Government and Contractors at W-P AFB were cited as prominent examples of improved management systems and techniques.

Shuttle

Processing activities were examined in some detail. Related issues and problems were found to be caused by "design" or "management" deficiencies. Significant improvement in STS processing turn-around time requires major, flight-hardware block modifications. These may not be cost effective when delivery system down-times (associated with lost launch opportunities and/or reduced "pounds of payload delivered to orbit") are taken into account. Specific operational tentpoles were identified and potential solutions described. Implementation of the Integrated Maintenance Information System (IMIS) segment of the ULCE system was noted as a viable candidate to improve paperwork system used currently for Shuttle processing. This would not incur any flight hardware modification costs, but would require a significant upfront investment in automated information acquisition and processing.

New Vehicles

Operations and management lessons learned from Shuttle can, if used in conjunction with technology advances and system design simplification, could significantly reduce operational life cycle costs for new vehicle programs.

Facilities

Initial facility costs may be kept low by modification of existing facilities and thereby influence basic vehicle configuration. Inefficiencies, however may be forced on the operators, resulting in large, unpredicted increases (or over-runs) in LCC. Scattered facilities, operations, and personnel office/work locations were cited as serious contributors to operational inefficiencies and increased LCC on the Shuttle, and other, programs.

PHASE 2

A conceptual expendable vehicle, perceived to meet available ALS criteria, was envisioned and assessed with the goal of identifying processing benefits, handicaps and inefficiencies. The concept was evaluated to identify those design cost drivers directly affecting the ALS objective of providing a capability to deliver payload to low earth orbit at a cost of $300/lb. These cost drivers should be eliminated or greatly simplified, from an operations viewpoint, to enable approaching the ALS cost reduction objectives. Figure 2 shows the six major operational/design areas identified. Items targeted for elimination or simplification to effect a dramatic cost reduction, compared to STS, are also identified. Volume 4 of the Phase 2 Final Report provides expanded details of the Operational Criteria.

Phase 2 conclusions relative to SLSOC are:

1. Simplified, expendable, unmanned vehicles of conventional technology / methodology, do not show promise of meeting $300/lb, LEO ALS goal even with highly simplified ground operations; $750 in FY-86 dollars is more likely.

2. Expendable booster cost can equal a significant portion of total expendable flight hardware costs. An easily maintained, reusable booster provides a way to reduce costs and approach the ALS goal.

3. Addition of a ballistic, or low L/D, P/A module to expendable core stage, or use of a series of similar recoverable engine pods, will require additional launch site facilities and ground support operations, even if agreed to by local environmental agencies. These additional operations

SIMPLIFIED LAUNCH SYSTEM OPERATIONAL CRITERIA (SLSOC)

MANAGEMENT & SYSTEM ENGINEERING

- M 1) ● PROCUREMENT
- M 2) ● DESIGN / BUILD TEAMS
- M 3) ● DEMING STYLE MANAGEMENT
- M 4) ● LIFE CYCLE COSTS
- M 5) ● DESIGN TO COST
- M 6) ● UNIFIED LIFE CYCLE ENGINEERING
- M 7) ● RISK MANAGEMENT
- M 8) ● RELIABILITY / OPERABILITY
- M 9) ● MAINTAINABILITY / SUPPORTABILITY
- M 10) ● LOGISTICS SUPPORT
- M 11) ● OPERATIONAL TEST REQUIREMENTS
- M 12) ● QUALITY ASSURANCE
- M 13) ● SAFETY
- M 14) ● SECURITY

ELIMINATE

- M 1) ○ MULTIPLE PRIME CONTRACTORS ON SAME PROGRAM
- M 6) ○ TIGER TEAMS FOR STATUS (Requires 100% Computer Connectivity)
- L 1)
- M 1) ○ SEPARATE DESIGN CONTRACTORS / VOLUMINOUS INTERFACE CONTROL
- M 12) ○ LARGE QUALITY INSPECTION TEAMS
- M 10) ○ CANNIBALIZATION
- M 4) ○ COST OVERRUNS & UNLIMITED LCC
- M 7) ○ EXORBITANT COST TO ATTEMPT ZERO RISK REQUIREMENTS

AVIONICS & SOFTWARE

- ● AUTONOMOUS VEHICLE
  - A 1) ● BIT / BITE (ON - BOARD CHECKOUT)
  - A 2) ● FAULT TOLERANT AVIONICS SUITE
  - A 1) ● VEHICLE HEALTH & STATUS MONITORING SYSTEM
  - A 4) ● MINIMAL LAUNCH CONTROL INTERFACE
  - A 1) ● RETURNED VEHICLE SELF - TEST FOR REFLIGHT
  - A 3) ● AUTONOMOUS G N&C
  - A 4) ● OPTICAL / IR / RF LINK ONLY TO GSE
- ● SOFTWARE
  - A 5) ● COMMON "CORE" SOFTWARE FOR C / O, LAUNCH, FLIGHT
  - A 5) ● OPERATIONS DATA OVERLAYS (C / O, LAUNCH, MISSION)

ELIMINATE

- A 6) ○ RELATED GSE
- A 4) ○ HARDWIRE CONNECTS TO GSE
- E 1) ○ GROUND POWER REQUIREMENTS

POWER

- E) ● LOW MAINTENANCE ENERGY STORAGE
- E) ● PROPELLANT GRADE FUEL CELLS
- E) ● STATE - OF - ART ENERGY SOURCES
- E) ● SYSTEM SIZED TO PROVIDE ON - BD PWR FOR GROUND OPERATIONS

ELIMINATE

- A 6) ○ RELATED GSE
- E) ○ GROUND POWER REQMTS

STRUCTURES & MATERIALS

- ● IMPROVED STRUCTURE
  - S 1) ● HIGH STRENGTH, LIGHT WEIGHT CRYO TANKS
  - S 2) ● STRUCTURAL INTEGRITY VERIFICATION
  - S 3) ● INTEGRAL TPS
- S 4) ● ORDNANCE
  - S 4.1) ● WEAPON DESTRUCT
  - S 4.2) ● LASER IGNITION
  - S 4.3) ● ACCELERATION / CLEVIS SEPARATION
  - S 4) ● NITINOL / E - M DEVICES

ELIMINATE

- S 3) ○ SEPARABLE TPS
- S 4) ○ ALL ORDNANCE
- S 4) ○ PROCESSING SAFETY RESTRICTIONS

PROPULSION

- ● INTEGRATED PROPULSION SYSTEM
  - P1) ● SIMPLIFIED ROBUST PROPULSION SYSTEM
  - P1.1) ● FULLY THROTTLEABLE ENGINES (MULTI-PHASE)
  - P1.2) ● SOFT ENGINE START
  - P1.3) ● TVC BY DELTA THRUST AND/ OR RCS / OR AERO
  - P1.4) ● ONE OXIDIZER / ONE FUEL

ELIMINATE

- P 2) ○ SEPARATE OMS AND RCS
- P 3) ○ HIGH MAINTENANCE TURBOPPUMPS
- P 4) ○ HYDRAULICS
- P 5) ○ HYPERGOLS
- P 6) ○ GN_2 / He ON-BOARD PURGES
- P 7) ○ GN_2 / He PRESSURE SYSTEM
- P 8) ○ GIMBALLED ENGINES
- P 9) ○ EXTENSIVE RECOVERY & REFURBISHMENT

FACILITIES & SUPPORT EQUIPMENT

- L 1) ● 100% COMPUTER CONNECTIVITY
- ● AUTOMATION
  - L 2) ● ELECTRONIC OMFs
  - L 3) ● TEXT AND GRAPHICAL DATA ACQUISITION
  - L 4) ● TEST REQUIREMENT VERIFICATION
- ● STAGE ASSEMBLY
  - L 5) ● INITIAL NEAR LAUNCH CENTER
  - L 5) ● FINAL AT LAUNCH CENTER
- L 6) ● HORIZONTAL PROCESSING
  - L 7) ● HORIZONTAL TRANSPORT
- ● PAYLOADS
  - L 10) ● ONE AUTONOMOUS CONTAINER
- ● PAD
  - L 8) ● BARREN PAD
  - L 9) ● ERECT / MATE STAGES AT PAD
  - L 8.1) ● DEEP WATER EXHAUST BUFFER
  - L 8) ● LIGHTNING / LIGHTING TOWER
  - L 8.2) ● FLY-AWAY CONNECTS ONLY
  - L 8) ● PROPELLANT FARM
  - L 6) ● PAVED TOW - WAY
- ● MOBILE EQUIPMENT
  - L 6 ● STANDARD AIRCRAFT TUG
  - L 6 ● STRAP-ON WHEELED DOLLIES
  - L 6 ● MOBILE CRANE
- ● BUILDINGS
  - L 6 ● HORIZONTAL PROCESSING FACILITY

ELIMINATE

- ○ AUTOMATION
  - L 1) ○ ISOLATED DATABASES
  - L 2) ○ PAPERWORK RELATED TO TEST
  - L 4) ○ REQUIREMENTS VERIFICATION
  - L 3) ○ PRINTED TRANSFER OF TEXT / DATA
- L 10) ○ PAYLOAD / VEHICLE INTEGRATION VERIFICATION TESTING
- L 9) ○ LIFTING VEHICLES CLEAR OF GROUND
- ○ PAD EQUIPMENT
  - L 4) ○ HARDWIRE CONNECTS
  - L 8.4) ○ ACCESS STRUCTURES
  - L 8.3) ○ SWINGARMS
  - L 8) ○ RETRACTING UMBILICALS
  - L 8.5) ○ T-O HOLD-DOWN
  - L 8.6) ○ DELUGE WATER
  - L 8.6) ○ SOUND SUPPRESSION WATER
  - L 8.1) ○ FLAME TRENCH / DEFLECTOR
  - L 8.7) ○ ECS
  - P 5) ○ He / GN_2 STORAGE
  - E) ○ GROUND POWER
  - L 7) ○ CRAWLER WAY
- ○ MOBILE EQUIPMENT
  - L 7) ○ CRAWLER / TRANSPORTER
  - L 7) ○ MOBILE LAUNCH PLATFORM
- ○ BUILDINGS
  - L 6) ○ VAB
  - L 6) ○ VPF
  - L 6) ○ RPSF

EXEC. SUMMARY
FIGURE 2

will impose a significant penalty on LCC with the probable result of reducing the capability to meet ALS goals.

PHASE 3

SYNOPSIS

The planning for Phase 3 projected that the Workshops would be presented in the July-August 1988 time period. Because of the Congressional delays in the appropriation of funds for the ALS Phase 2 contractors, the Workshops were reprogrammed and presented in March-April, 1989 (refer to Figure 3).

The presentation material used at the workshops was based on the SLSOC and is included as Volume 2 of this report. The Workbook Reference Document, Volume 3 of this report, was provided to each of participants. Material presented in all three Workshops was well accepted. There was good contractor and government participation and dialogue from the attendees in five of the six SLSOC areas discussed (refer to Figure 2). No one felt that it was within their "responsibility" to address the management problems highlighted in the Study. Other studies have reported, including Dr. Deming, that the man on the floor can only resolve 15 -20 percent of the problems he encounters in his work -- the other 80 - 85 percent require management attention to get resolved.

Wiley C. Bunn, MSFC Director of Quality Assurance, published an article in Quality & Productivity Awareness and distributed across NASA Centers that points out the need: for management support -- all the way from the top:

> *Upon Dr. Deming's arrival at the Ford Motor Company to address the executives, or so the story goes, the CEO introduced him to the assembly and then began to leave the room. Dr. Deming turned and followed him out. The CEO stopped and asked Dr.Deming why he was leaving. Deming replied,* ***If you are not interested, there is nothing I can suggest to help your company."***

This item, again, points out the need for management direction and support -- all the way from the CEO level.

After the formal presentation of the workshop material on the first day of each session, the contractor was given time to query the SGOE/T Workshop team members on specific points of interest. These points were discussed during the second day.

At the completion of each workshop the SGOE/T team received requests for additional information. These requests were for additional information that the team did not present during the workshop. The requested material or the

identification of an appropriate contact from which the material can be obtained has been supplied.

SUMMARY

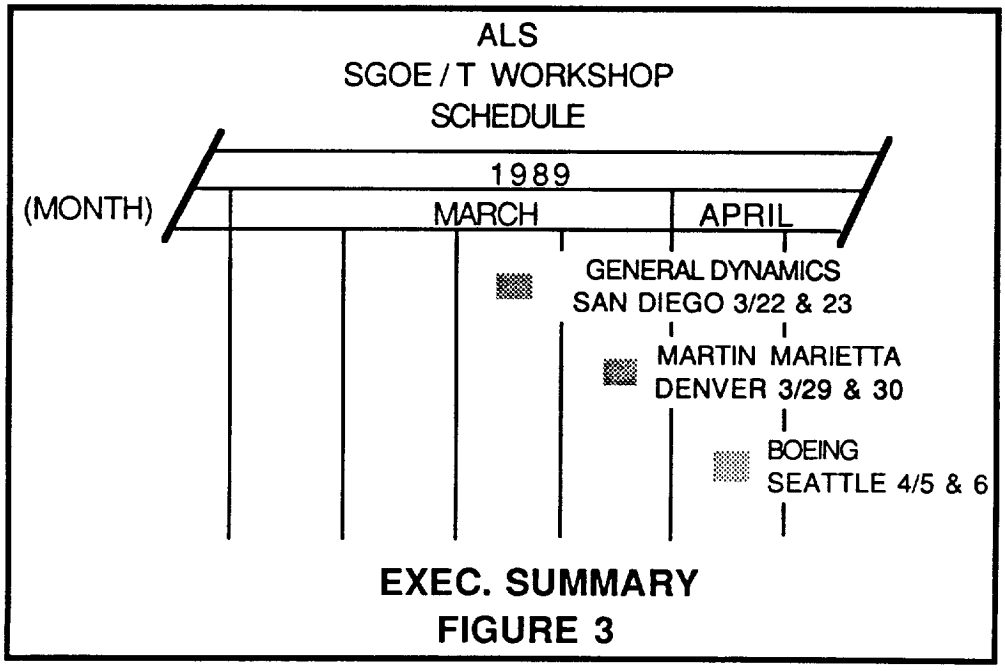
It was apparent to the SGOE/T team members that there was a genuine interest, among the attendees, in reducing the LCC for the next generation launch vehicle. The ALS program has made it very clear that performance may have to take a back seat to operational efficiency in order to accomplish its goal of $300/lb to LEO.

Although the technical issues to meet this goal are significant, the SGOE/T team members believe that the goals are achievable in many areas. All contractors are interested in addressing the technical issues, but few evidenced interest in tackling the management problems identified in the SLSOC. It has been apparent, during all 3 phases of this contract effort, that there are two major contributors to the exorbitant LCC of our current launch systems. The first of these is a direct result of the combination of Congressional budgetary practices, and the second is the archaic government

and contractor management methodologies prevalent throughout the system. Significant management changes must be mandated at the highest levels before significant changes can be realized at the working level.

Men can live without air for a few minutes,
without water for about two weeks,
without food for about two months, and
without a new thought for years on end.

Kent Ruth:



EXEC. SUMMARY
FIGURE 3

Volume 1	Executive Summary
Volume 2	Ground Operations Evaluation
Volume 3	Final Presentation Material
Volume 4	Preliminary Issues Database (PIDB)
Volume 5	Technology Information Sheets (TIS)

Volume 1
The Executive Summary provides an overview of major elements of the Study, reviews the findings, and reflects development of recommendations resulting from the Study.

Volume 2
The Ground Operations Evaluation volume describes the breath and depth of various Study elements selected as a result of an operational analysis conducted early in the Study. Analysis techniques used for the evaluation are described in detail. Elements selected for further evaluation are identified, results of the analysis documented, and a follow-up course of action recommended. The background and rationale for developing recommendations for the current Shuttle or for future programs is presented.

Volume 3
The Final Presentation Material volume contains the final version of charts used in Phase 1 Oral Briefings at KSC on April 6, 1987, and at the STAS (Space Transportation Architecture Study) IPR-5 (In-Progress Review) held at MSFC on April 8, 1987.

Volume 4
The Preliminary Issues Database (PIDB) was assembled very early in the Study as one of the fundamental tools to be used throughout the Study. Data were acquired from a variety of sources and compiled in such a way that the data could be easily sorted in accordance with a number of different analytical objectives. The computerized database system significantly expedited sorting and flexibility as well as providing a user-friendly tool for the analyst. Volume 4 summarizes information contained in the PIDB and provides the reader with the capability to manually find items of interest. How that information was used in this Study is explained in greater detail in Volumes 2 and 3.

Volume 5
The Technology Information Sheets (TIS) volume was assembled in database format during Phase 1 of the Study. This document was designed to provide a repository for information pertaining to 144 major, OMI-controlled (Operations and Maintenance Instructions) operations in the OPF, VAB and PAD. It provides a way to accumulate, for each task, information about required crew sizes, operations task time duration, identification of where that time is considered serial or parallel, special GSE required, and identification of potential application of currently existing technology, or the need for the development of new technology items. Manhour data by OMI (procedure) is incomplete because the Shuttle Processing Contractor was not required to accumulate the data to that level of detail.

NOTE: Volumes 1 and 2 are being widely distributed. Volume 3 is a copy of presentation material already distributed and Volumes 4 and 5 are database material that will not be distributed unless requested. Copies of the report will be placed in libraries at NASA HQ., JSC, KSC, MSFC and NASA RECON. Individual volume copies may be obtained by forwarding a request to W. J. Dickinson, KSC PT-FPO, (407) 867-7705.

Volume 1		Executive Summary
Volume 2		Final Presentation Material
Volume 3		Space-vehicle Operational Cost Drivers Handbook
	Part 1	Checklists
	Part 2	Related Reference Information
Volume 4		SLSOC (Simplified Launch System Operational Criteria)
Volume 5		Technology References
Volume 6		Circa 2000 System Operational Requirements

Volume 1

The Executive Summary provides an overview of major elements of the Study. It summarizes the Study analytic efforts, the documentation developed, and reviews the recommendations resulting from the analyses conducted during Phase 2 of the Study.

Volume 2

The Phase 2 Final Oral Presentation Material volume contains the charts used in the Final Oral Presentations for Phase 2, at KSC on April 6, 1988. A brief, overall review of the Study accomplishments is provided. An indepth review of the documentation developed during the last quarter of Phase 2 of the Study is presented. How that information was used in this Study is explained in greater detail in Vols. 3 and 4. An initial look at the topics planned for the upcoming Workshops for Government/Industry is presented along with a cursory look at the results expected from those Workshops.

Volume 3

The Space-vehicle Operational Cost Drivers Handbook (SOCH) was assembled early in Phase 2 of the Study as one of the fundamental tools to be used during the rest of the Phase. The document is made up of two parts -- packaged separately because of their size.

Part 1 Presents, in checklist format, the lessons learned from STS and other programs. The checklist items were compiled so that the information would be easily usable for a number of different analytical objectives, and then grouped by disciplines or gross organizational, and/or functional responsibilities. Content of the checklists range from 27 management; 11 system engineering; 8 technology; and 19 design topics -- with a total of 793 individual checklist items. Use of this Handbook to identify and reduce Cost Drivers is recommended for designers, Project and Program managers, HQ Staff, and Congressional Staffs.

Part 2 Contains a compilation of related reference information about a wide variety of subjects including ULCE, Deming, Design/Build Team concepts as well as current and previous space launch vehicle programs. Information has been accumulated from programs that range from, Saturn/Apollo, Delta, Titan, and STS to NASP and Energia.

Volume 4

The SLSOC (Simplified Launch System Operational Criteria) document was developed from the generic Circa 2000 System document, Vol. 6; is similar in content; and also indicates the manpower effect of the elimination of many STS-type cost drivers. The primary difference between the two documents is the elimination of all generic Circa 2000 requirements (and support) for manned-flight considerations for the ALS vehicle. The data content of the two documents, while similar in nature, was reorganized and renumbered for SLSOC so that it could be used as the basis for various panels and subpanels in an ALS Workshop.

Historical data is the basis for the conclusion that incremental improvements of technology and methods cannot significantly improve LCC (by an order-of-magnitude) without major surgery. A system enabling the development of a radically simplified operational concept, reflected in SLSOC, was included so that proposed designs (and operations) could be compared to systems providing for simplicity -- rather than the current STS complexity.

The identified operational cost drivers from STS plus other historical data were used as background reference information in the development of each example concept designed to eliminate cost drivers. These example concepts, when integrated, would support an order-of-magnitude cost reduction in current (STS), exorbitant Life Cycle Costs (LCC). Individual operational requisites were developed for each element in the associated management systems, integration engineering, vehicle systems, and supporting facilities. These have associated rationale, sample concepts, identification of technology developments needed, and technology references to abstracts. The technology abstracts are provided in a separate volume, Vol. 5.

Technology changes almost daily, thus past trade studies may no longer be valid. In addition, old "trades" often used inaccurate estimates of "real" operational costs. Vehicle designs are compromises and have been performance oriented with operations methods/techniques based on those designs. It is the intent of our example concepts in the SLSOC to stimulate design teams to improve or replace conventional design approaches. Obviously, it is up to the responsible program design teams to provide design solutions to resolve operational cost drivers.

Volume 5

This document provides a repository for the Technology References for the SLSOC and the CIRCA 2000 System documents. The technology references, mostly from NASA RECON, are supplied to the reader to facilitate analysis on either the SLSOC or the CIRCA 2000 System documents. Some data references were also obtained via DIALOG. If more technical information is desired by an analyst, he must obtain the additional documentation thru his library or from some other appropriate source. The XTKB (EXpanded Technology Knowledge Base) provided a user-friendly tool for our analyses in identifying and obtaining the computerized database reference information contained in this document. Thousands of abstracts were screened to obtain the 300 plus citations pertinent to SLSOC in this Volume.

Volume 6

The Circa 2000 System Operational Requirements were developed using STS as a working data source. We identified generic operations cost drivers resulting from performance-oriented vehicle design compromises and the operations methods/techniques based on those designs. Those Cost Drivers include high-cost, hazardous, time & manpower-consuming problem areas involving vehicles, facilities, test & checkout, and management / system engineering. Operational requisites containing rationale, example concepts, identification of technology developments needed, and identification of technology references using available abstracts were developed for each Cost Driver identified. Elimination of cost drivers significantly reduces recurring costs for prelaunch processing and launch operations of space vehicles.

NOTE: Volumes 1,3,4 and 5 are being widely distributed. Volume 2 is a copy of presentation material already distributed and Volume 6 will be distributed only on request. Copies of the full report will be placed in libraries at NASA HQ., JSC, KSC, MSFC and NASA RECON. Individual volume copies may be obtained by forwarding a request to W. J. Dickinson, KSC PT-FPO, (407) 867-7705.

Volume 1
The Executive Summary provides an overview of the major elements of the study, summarizes each of the study phases, and provides an overview of the activities of Phase 3.

Volume 2
The Phase 3 Final Oral Presentation material contains the view charts used during the Workshops presented at each of the three ALS contractor sites. This data was used in conjunction with the expanded level of details contained in volume 3.

Volume 3
The Simplified Launch System Operational Criteria (SLSOC) workshop handbook is a recipe book for simplified ground operations that can result from application of concepts that compromise ballistic performance for "usability" and "reliable launch-on-schedule" capabilities.

Volume 4
The Work Volume Indicators are a condensed compilation of space shuttle ground processing functions, headcount, and work volume indicators. The data was compiled from the processing of Challenger's last mission, 51-L. The information herein are intended to show why 6110 people were required to accomplish the repetitive, vehicle-related ground support of operations at Kennedy Space Center.

NOTE: Volume 1, Executive Summary, will be distributed to the normal Study Distribution List. Volumes 2, 3, and 4 were distributed during the Workshops and will be distributed only on request. Copies of the total Phase 3 report will be placed in libraries of NASA Centers and in NASA RECON. Individual volume copies may be obtained by forwarding a request to W. J. Dickinson, KSC PT-FPO, (407) 867-7705.

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16. Abstract

Objective of Phase 3 was to apply the "lessons learned" and analytical data developed during Phases 1 and 2. Material was developed for ground operations cost driver workshops conducted at the ALS vehicle and propulsion contractor plant sites. The ALS contractor workshops highlighted: 1) Simplified Launch System Operational Criteria (SLSOC), 2) supporting rationale, and 3) the need to evaluate impact(s) of ground operations on their various trade studies, analyses, and design concepts.

Conclusions of the study indicate the next generation orbital access vehicle CAN provide an order-of-magnitude life cycle cost reduction, compared to STS, by placing the very highest priority on operability and maintainability (even if sacrificing some aspects of ballistic performance). And equally important is the need of addressing/correcting antiquated budgetary practices of the Congress, and methodologies at government/contractor management interfaces. Significant management changes must be mandated at the very highest levels before significant changes can be realized at the working level.

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